Smart Sensor for Extended Range Optical Underwater Imaging

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LONG TERM GOALS

The long range goals of this program fall into several areas: 1) Operational, 2) Scientific, 3) Computational. In an operational sense, we seek to demonstrate the feasibility of a new type of underwater imaging system which is based on using solid state components instead of mechanical ones. In a scientific sense we seek to understand the propagation of light in the coastal environment that this imaging system will be operating in. In a computational sense, we seek to develop processing algorithms to optimize the quality of information that is being sensed optically. Using the output from the solid state imaging array, we will be able to construct a record of the time varying radiance that is incident upon the camera. Using this information in conjunction with a model of the environment we will develop the capability to simultaneously estimate both the environment and also the reflectivity and topography of the bottom.

OBJECTIVES

The objective of this program is to come up with a "proof of concept" demonstration unit which is a prototype of an extended range imaging system which also has the ability to measure microbathymetry. Year 1 consisted of assembling the system from existing commercially available components in order to gain familiarity with the technology and to uncover any hidden problems that we did not anticipate. Efforts to calibrate the system were also performed. In year two, (this year) we have fabricated a seagoing version of the system that was deployed on a towed body. In year 3, the system will be taken to a coral reef environment, as part of the COBOP program where it will be used to measure the high resolution bathymetry of a coral reef. The system is thus anticipated to be"operational" by the third year. An additional goal of the project is to create a system that can be deployed from an AUV. This includes the use of a real time operating system which can be used in an autonomous mode in addition to a self-contained package which is suitable for deployment on an AUV.

APPROACH

The basic approach of our program is to use the latest developments in both light generation technology and also sensors in concert with the newest version of PC computers to produce a system which offers an affordable and reliable way of achieving the dual goals of both extended range imaging and also small scale bathymetry. The system configuration consists of a pulsed Nd:Yag laser, a set of galvinometers for directing the beam, a one dimensional CCD array consisting of 1024 elements for recording the reflected light flux, and the necessary sub-surface computers and electronics to drive the system component. Year 1 efforts consisted of designing the system, lab experiments and the start of system fabrication. Year 2 efforts consisted of several at-sea deployments of the system. Year 3 will allow us to refine the field deployable hardware and also develop signal and image processing algorithms to process the data.

The present configuration of the system consists of a surface computer, an electro-optic tow cable and a sub-surface delta wing with transmitting and receiving optics. In year 2, this year, the laser has been

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located on the surface, however, in year 3, the laser will be relocated to a sub-surface housing.

WORK COMPLETED

During this year, a seagoing version of the system was fabricated and tested in two cruises. One cruise, whose goal was to verify the communication link between the surface was performed in June, 1997. In Sept, 1997, a second cruise was performed which tested all of the optical component of the system in addition to the sensor package. In order to prepare for these cruises a great many tasks were accomplished: Hardware developments: (1) fabrication and deployment of an electro-optical cable. (2) fabrication of all housings for transmitters, receivers, and all sub-surface electronics. (3) configuration of all of the hardware on the Endeco Delta wing, (4) fabrication of all optical components consisting of (a) surface optics to couple the laser into the fiber optic cable, (b) subsurface optical components to couple the laser light into the scanning galvinometers, (c) ancillary optics for the camera system. Software developments: (1) development of a client/server software system between the subsurface computer and the surface computer which allowed the real time display of data. (2) development of a Graphical User Interface (GUI) for the user to view data and also interact with the system.
(4) development of custom real-time system hardware which synchronized the firing of the laser with the exposure of the camera. (3) Integration of laser, camera and all sensor data into a software data stream which was transmitted to the surface computer.

RESULTS

Our results, to date, of the year 2 work indicate that our system development is proceeding on track and that we should have a fully operational "sea-going" version of the system, ready to be deployed on the first COBOP cruise for May, 1998. The above figure documents the ability of the system to obtain at sea data which consists of depth, temperature, yaw, pitch and roll of the package. In addition, image data, from an underwater NTSC camera that was deployed on the cruise indicated to us that the laser, scanners, and the light generation equipment was working correctly.

IMPACT/APPLICATIONS

The development of this instrument will have a significant impact on many scientific and military programs. In the scientific realm, there is a great need for measuring the small scale bathymetry (cm's) of underwater objects. The device that we are building will have the ability to resolve not only the albedo of the bottom but also the detailed topography of it on centimeter scales. A survey of competing technology reveals that this information can only be obtained, currently, using stereo photogrammetry. This procedure is extremely laborious and time consuming as substantial human intervention is necessary to obtain 3-dimensional topography from stereo photos. In addition, underwater stereo photogrammetry presents a special set of problems in high scattering environments. In the military realm, there is a great need for identifying the topography of buried objects that have no reflectivity difference between themselves and their surroundings, in particular, bottom mines..

TRANSITIONS

We are currently in contact with members of the MCM community to inform them of our developments. Since we are going to have a working system in Year 3, a host of opportunities exist for testing our platform. In addition to the MCM integration, we have been talking
to Dr. Jeff Simmen, ONR Acoustics program manager. Dr. Simmen is interested in using our instrument to measure bottom roughness for a program in high frequency acoustics related to bottom

scattering in the 1998, 1999 time frame.

RELATED PROJECTS

Jaffe's lab has several underwater optical imaging systems under deveolopment including multispectral underwater imaging and a new system to measure the fraction of photosynthetically active reaction centers. The synergy between these projects allows us to maintain an excellent facility for exploring new technology for underwater imaging.